Phytosanitary condition and yield of wheat (*Triticum aestivum*) and einkorn wheat (*Triticum monococcum*) grown in organic and conventional farming systems

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Abstract

Maneva, V. & Atanasova, D. (2018). Phytosanitary condition and yield of wheat (Triticum aestivum) and einkorn wheat (Triticum monococcum) grown in organic and conventional farming systems. *Rastenievadni nauki*, *55*(3), 3-9

The experiment was conducted in the period 2013-2016 on the experimental fields of Institute of Agriculture in Karnobat, Bulgaria. Wheat and einkorn were grown in organic and conventional farming systems. The effect of the type of farming on the phytosanitary condition and the yield of the crops was studied and compared. After the experiments, it was established that einkorn wheat is more resistant to diseases, pests and weeds than wheat in both farming systems. Weed infestation in both crops was higher in organic farming and in wheat the density of the weeds was higher, too. Both crops had greater yield in conventional farming. The type of farming system used in growing the crops had a significant effect on the yield, with wheat being the more susceptible one.

Keywords: wheat; einkorn; organic farming; phytosanitary condition; yield

Cereals are some of the most widely distributed crops in Bulgaria. Besides growing them in conventional farming systems, they are also major crops grown in organic farming. The use of organic farming systems requires sustainable methods (crop rotation, mechanical cultivation, maintaining soil fertility by means of green manure, organic pest control), which exclude the use of synthetic fertilizers, pesticides and growth regulators (Atanasova and Koteva, 2009; Bozhanova and Dechev, 2009; Atanasova et al., 2014; Seidel et al., 2017; Shah et al., 2017). Hulled wheat species (einkorn, emmer, spelt) are presumed to be an alternative to bread wheat in organic agriculture since the yield penalty is less pronounced under organic farming and generally higher prices can be achieved for specialty grains (Konvalina et al., 2014). Mäder et al. (2002), Seufert et al. (2012) and Ponisio et al. (2015) have found that crop yields are 20% lower in organic systems, although input of fertilizer and energy was reduced by 34 to 53% and pesticide input by 97%. Romero et al. (2008) have found that organic practices produce an increase in weed cover, species richness and Hill's first order diversity (but not in equitability), as well as a shift in weed vegetation composition, which favoured potentially rare arable, broad-leaved, insect-pollinated and legume weeds. Weed diversity was concentrated in crop edges, especially in weed communities of conventional cereal fields, which were found to be more spatially heterogeneous than the organic ones.

The aim of this study was to report the effect of type of farming on the phytosanitary condition and yield of wheat and einkorn wheat.

MATERIALS AND METHODS

The experiment was conducted in the period 2013-2016 on the experimental fields of the Institute of Agriculture in Karnobat. Wheat (*Triticum aestivum*) variety Miryana and einkorn (*Triticum monococcum*) (ancient wheat, local race) were grown in organic and conventional farming systems. The organic cultivation was performed on the certified field for organic farming at the Institute of Agricul-

ture in Karnobat. Both farming systems had experimental plots sown with wheat and einkorn in the size of 250 m^2, in four replications, a total of 0.1 ha per crop. The size of the whole experimental plot was 0.4 ha. Sowing-time was the optimal period between September 20th and September 30th, wheat (*Triticum aestivum*) were sown at 550 seeds/m^2 and einkorn (*Triticum monococcum*) at 450 seeds/m^2, the predecessor was a mix of peas and sunflower, the fertilizer used was N_{10}.

In the conventional farming system, the crops were cultivated by the accepted standard technologies, including fertilization with N_{10} and spraying with pesticides (in the tillering phase of cereals - tribenuron methyl + fenoxaprop-P-ethyl and tebuconazole + spiroxamine + triadimenol). The organic farming does not employ any chemization and any fertilization.

The phytosanitary condition of both crops was followed up in both farming systems and the yields obtained in the studied years were compared.

The phytosanitary conditions were observed in the wheat and eincorn during April - May. Weeds were determined according to Delipavlov et al. (2003), number/m^2. The aphid's population size was determined by direct measurement at 10 locations on 10 stalks of each crop (Dewar et al., 1982). Taxonomic analyzes of the aphids are made according to Van Emden (1972) and Blackman and Eastop (2000). The state of the crops in terms of diseases was observed during the growing season. Readings were carried out on the route method, via the plants (Stepanov and Chumakov, 1972; Krivchenko, 1984).

The data was processed by analysis of variance (BIO program).

RESULTS AND DISCUSSION

The climate in Southeastern Bulgaria is transitional continental with average annual rainfall of 549 mm. Winter is comparatively warm, spring is short and cool, summer is hot and dry, autumn is long and warm. The studied period was marked by excessive rainfall and in the first year it was by 8% more than the multi-annual values, in the second – by 40%, in the third – by 30% more. Rainfall was unevenly distributed by months, but provided humidity during the specific periods and the conditions for growing cereal crops were favorable (Fig. 1).

The warm and wet weather during the three years of the study (Fig. 1) created favorable conditions for occurrence of diseases in wheat. As more susceptible than einkorn wheat, diseases were found in it in both farming systems (Table 1).

Ustilago tritici was not found in the conventional farming system, probably due to decontamination of seeds whereas in organic farming uncontaminated seeds were used, which led to occurrence of the disease. In organic farming, *Erysiphe graminis* was not found in wheat in the three years of the study,

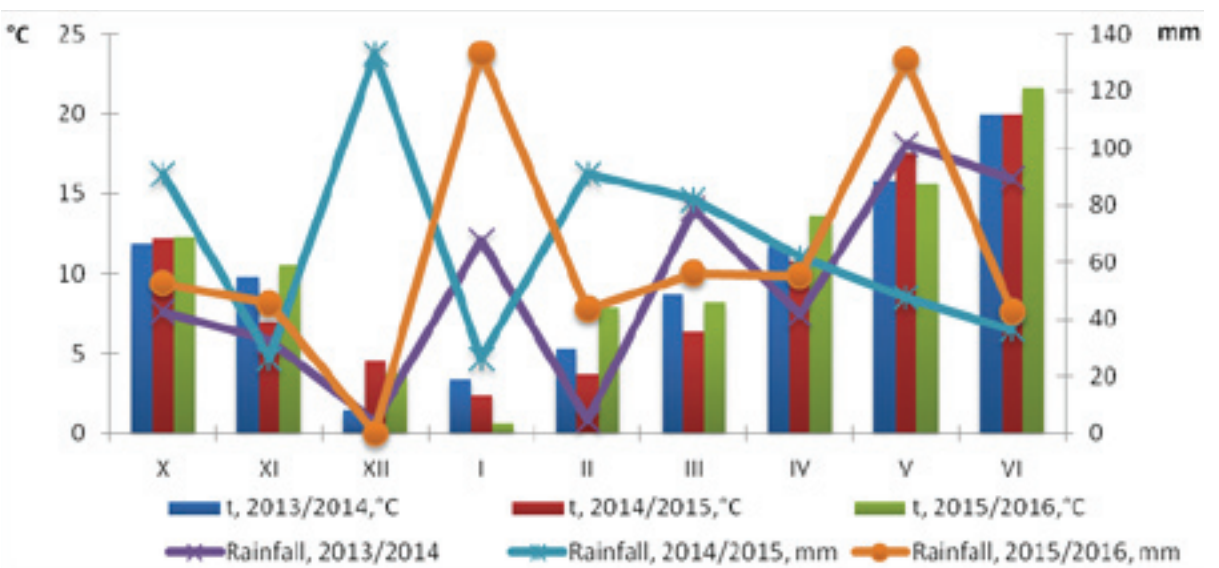

Figure 1. Agrometeorological characterization of the study period

which was probably due to the thinner crops and the inability to create suitable microclimate for its development. The thinner crops in organic farming were due to the smaller amount of nutrients in the soil and the weaker development of the plants. The established diseases were not above the economic threshold of damage in both farming types.

The monitoring on einkorn wheat over the three years of the study has found no diseases in both farming systems, which supported the statement of Mamluk and Van Slageren (1993), Yao et al. (2007), Zhu et al. (2009) and Zaharieva and Monneveux (2014) that einkorn wheat is resistant to diseases.

In wheat pests were found in both farming systems (Table 2).

In the conventional farming system four predominant species of aphids were reported (Table 2), whereas in the organic system only *Sitobion avenae* L. was reported. Aphids probably prefer wheat in conventional farming due to the fact that it is fertilized and its green mass is well developed and more attractive to them. Whereas the lower amount of nutrients in organic farming led to an early roughening of the plants and they become less attractive to the aphids. *Eurygaster* sp., *Aelia* sp. and *Haplothrips tritici* Kurd. were reported in wheat in both farming systems and their density was under the economic threshold of damage.

The phytosanitary monitoring on einkorn wheat in both farming systems established no pests, which supported the statement of Mamluk and Van Slageren (1993), Yao et al. (2007), Zhu et al. (2009) and Zaharieva and Monneveux (2014) that einkorn wheat is resistant to pests.

The phytosanitary monitoring conducted to study the species composition of the weeds in wheat and einkorn wheat in the conventional and organic farming systems demonstrated that in autumn all the crops were infested by the ephemeral weeds (Tables 3, 4, 5). Winter/spring and early spring weeds were most widely observed in both farming systems (Tables 3, 4, 5).

After the weeds were reported in spring it was established that the widest variety of weed species was observed in the organic system of crop cultivation and particularly in wheat – 15 species in 2014, 10 in 2015 and 10 in 2016. The lowest species diversity was observed in the conventional farming fields and particularly in wheat. This is due to the fact that after long-term application of herbicides, certain

Table 1. Species composition of diseases in wheat grown in two farming systems (2013-2016)

Disease	Conventional farming	Organic farming	Disease threshold
Ustilago tritici	-	+	5 spike/100 m^2
Puccinia recondita	+	+	5% attacked leaves
Erysiphe graminis	+	-	10% attacked leaves
Septoria tritici	+	+	15% attacked plants

+ single plants

Table 2. Species composition of pests in wheat grown in two farming systems (2013-2016)

Pests	Conventional farming	Organic farming	Pests threshold
Sitobion avenae L.	+	+	10 nb/plant
Schizaphis graminum Rond.	+	-	10 nb/plant
Rhopalosiphum maydis Fitch.	+	-	10 nb/plant
Rhopalosiphum padi L.	+	-	10 nb/plant
Eurygaster sp.	+	+	2-4 nb/m^2
Aelia sp.	+	+	2-4 nb/m^2
Haplothrips tritici Kurd.	+	+	10 nb/plant

+ single pests

Table 3. Species composition of weeds in wheat and einkorn wheat in both farming systems, 2014

Weeds	Wheat		Einkorn	
	Conventional farming	Organic farming	Conventional farming	Organic farming
Anthemis arvensis L.	1	1	-	-
Caucalis daucoides L.	-	1	-	-
Capsella bursa-pastoris (L.) Medic.	1	2	-	-
Centaurea cyanus L.	-	1	-	-
Consolida regalis S.F. Gray.	-	1	-	-
Consolida orientalis L.	1	-	-	-
Papaver rhoeas L.	2	3	3	3
Polygonum convolvulus L.	3	4	-	-
Polygonum aviculare L.	2	2	-	-
Sinapis arvensis L.	2	2	2	2
Vicia hirsute (L.) S.F.Gray	-	2	-	-
Vicia striata M.B.	-	2	-	-
Veronica hederifolia L.	2	2	3	3
Viola tricolor L.	2	1	2	3
Avena spp.	1	1	-	1
Bromus ssp.	2	-	-	-
Hordeum murinum L.	-	1	-	-
All kinds of weeds	**11**	**15**	**4**	**5**
Total weeds, nb/m²	**19**	**26**	**10**	**12**

Table 4. Species composition of weeds in wheat and einkorn wheat in both farming systems, 2015

Weeds	Wheat		Einkorn	
	Conventional farming	Organic farming	Conventional farming	Organic farming
Anthemis arvensis L.	4	3	2	2
Caucalis daucoides L.	-	1	-	-
*Consolida orientalis*L.	-	1	-	-
Papaver rhoeas L.	4	4	2	2
Polygonum convolvulus L.	2	1	-	-
Polygonum aviculare L.	-	1	-	-
Sinapis arvensis L.	2	2	1	1
Veronica hederifolia L.	2	2	3	2
Viola tricolor L.	2	2	2	2
Bromus ssp.	-	1	-	-
All kinds of weeds	**6**	**10**	**5**	**5**
Total weeds, nb/m²	**16**	**18**	**10**	**9**

weed species develop. The einkorn wheat crops in both farming systems were weed infested to a significantly lower degree than wheat. The weed density was greatest in the organic cultivation of wheat – from 16 to 26 weeds/m^2 (Tables 3, 4, 5).

After processing the data on the yield of wheat and einkorn wheat in the three years in both farming systems, it was established that it was higher in conventional farming and proven lower with 74.67% at $P_{5\%}$ in the organic system for einkorn wheat (Fig. 2) and with 55.28% at $P_{0.1\%}$ for wheat (Fig. 3).

The data analysis established that the main factor affecting the yield was the type of farming system – 97.46% for einkorn wheat (Table 6) and 98.70% for

Table 5. Species composition of weeds in wheat and einkorn wheat in both farming systems, 2016

Weeds	Wheat		Einkorn	
	Conventional farming	Organic farming	Conventional farming	Organic farming
Anthemisarvensis L.	3	-	1	-
Capsella bursa-pastoris (L.) Medic.	-	1	-	1
Consolida orientalis L.	1	1	-	1
Papaver rhoeas L.	3	3	2	2
Polygonum convolvulus L.	1	1	-	-
Polygonum aviculare L.	-	1	-	-
Sinapis arvensis L.	4	1	2	1
Veronica hederifolia L.	2	1	2	1
Viola tricolor L.	2	8	1	5
Avena spp.	2	2	-	-
Bromus ssp.	1	1	-	-
All kinds of weeds	**9**	**10**	**5**	**6**
Total weeds, nb/m^2	**19**	**20**	**8**	**11**

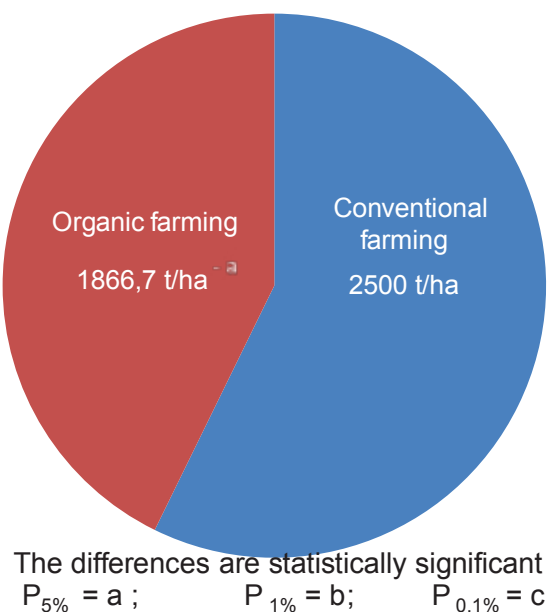

Figure 2. Average yield of einkorn, grown in two types of farming (2013-2016), t/ha

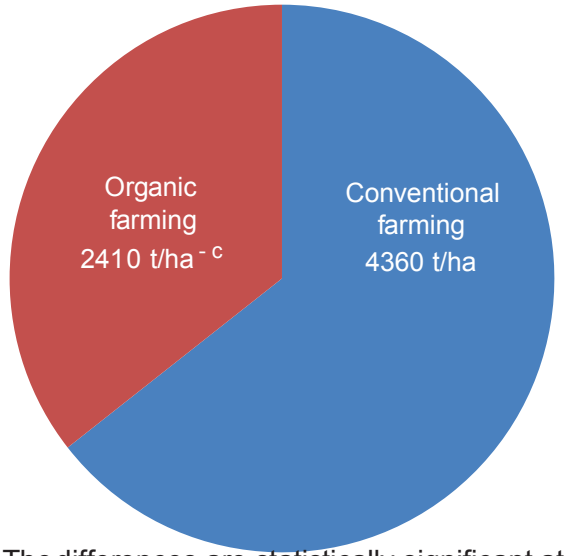

Figure 3. Average yield of wheat, grown in two types of farming (2013-2016), t/ha

Table 6. Analyses of variance for grain yield of einkorn, grown in two types of farming

Source of variation	SQ	DF	η^2 (%)
Total variation	6171.33	5	
Years	4.33	2	0.07
Types of farming	6016.67	1	97.46
Accidental factors	152.33	2	2.47

Table 7. Analyses of variance for grain yield of wheat, grown in two types of farming

Source of variation	SQ	DF	η^2 (%)
Total variation	57791.50	5	
Years	679	2	1.17
Types of farming	57037.5	1	98.70
Accidental factors	75	2	0.13

wheat (Table 7). Considering that there is no development above the threshold of diseases and pests, the yield is not influenced by pests.

CONCLUSIONS

Einkorn wheat (*Triticum monococcum*) is more resistant to diseases, pests and weeds than wheat (*Triticum aestivum*) in both farming systems. Weed infestation in both crops is greater in organic farming and the weed density is greater in wheat. Higher yields were obtained from both crops in conventional farming. The type of farming system used in cultivating the crops has a significant effect on yield, with wheat being the more susceptible one.

REFERENCES

Atanasova, D. & Koteva, V. (2009). Effects of crop rotation on weeds in preparing agricultural field through organic farming. *Journal of Balkan Ecology*, *12*(1), 65-67.

Atanasova, D., Zarkov, B. & Maneva, V. (2014). Influence of predecessor on productivity on barley and wheat in organic farming. *Field Crops Studies*, *9*(2), 297-302 (Bg).

Blackman, R. L., & Eastop, V. F. (2000). *Aphids on the world's crops: an identification and information guide* (Second Edition). New York, John Wiley & Sons Ltd.

Bozhanova, V. & Dechev, D. (2009). Problems and perspectives related to the cultivation of cereal species in a biological way. In: *Economics and development of the knowledge-based society*, International Scientific Conference, June 4-5th 2009, Stara Zagora, Bulgaria (Bg).

Delipavlov, D., Cheshmedzhiev, I., Popova, M., Terziyski, D. & Kovachev, I. (2003). *Determination of plants in Bulgaria*. Plovdiv, Agrarian University (Bg).

Dewar, A. M., Dean, G. J., & Cannon, R. (1982). Assessment of methods for estimating the numbers of aphids (Hemiptera: Aphididae) in cereals. *Bulletin of Entomological Research*, *72*(4), 675-685.

Konvalina, P., Stehno, Z., Capouchová, I., Zechner, E., Berger, S., Grausgruber, H., Janovska, D. & Moudrý, J. (2014). Differences in grain/straw ratio, protein content and yield in landraces and modern varieties of different wheat species under organic farming. *Euphytica*, *199*(1-2), 31-40.

Krivchenko, V. (1984). *Stability of grain grains to pathogens of headaches*. Moscow, Kolos (Ru).

Mäder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P., & Niggli, U. (2002). Soil fertility and biodiversity in organic farming. *Science*, *296*(5573), 1694-1697.

Mamluk, O. F., & Van Slageren, M. W. (1993). Resistance to common bunt, yellow rust, leaf rust and Septoria tritici blotch¡ n wild einkorn and wild emmer wheat. *Phytopathologia Mediterranea*, *32*(1), 14-19.

Ponisio, L. C., M'Gonigle, L. K., Mace, K. C., Palomino, J., de Valpine, P., & Kremen, C. (2015). Diversification practices reduce organic to conventional yield gap. *Proc. R. Soc. B*, *282*(1799).

Romero, A., Chamorro, L., & Sans, F. X. (2008). Weed diversity in crop edges and inner fields of organic and conventional dryland winter cereal crops in NE Spain. *Agriculture, Ecosystems & Environment*, *124*(1-2), 97-104.

Seidel, R., Moyer, J., Nichols, K., & Bhosekar, V. (2017). Studies on long-term performance of organic and conventional cropping systems in Pennsylvania. *Organic Agriculture*, *7*(1), 53-61.

Seufert, V., Ramankutty, N., & Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. *Nature*, *485*(7397), 229-232.

Shah, A., Askegaard, M., Rasmussen, I. A., Jimenez, E. M. C., & Olesen, J. E. (2017). Productivity of organic and conventional arable cropping systems in long-term experiments in Denmark. *European Journal of Agronomy*, *90*(Oct. 2017), 12-22.

Stepanov, K. & Chumakov, A. (1972). *Forecast of Diseases in Agricultural Plants*. Leningrad, Kolos (Ru).

Van Emden, H. F. (1972). *Aphid technology.* Academic Press London, 107-110.

Yao, G., Zhang, J., Yang, L., Xu, H., Jiang, Y., Xiong, L., Zhang, C., Zhang, Z., Ma, Z., & Sorrells, M. E. (2007). Genetic mapping of two powdery mildew resistance genes in einkorn (Triticum monococcum L.) accessions. *Theoretical and Applied Genetics*, *114*(2), 351-358.

Zaharieva, M., & Monneveux, P. (2014). Cultivated einkorn wheat (Triticum monococcum L. subsp. monococcum): the long life of a founder crop of agriculture. *Genetic Resources and Crop Evolution*, *61*(3), 677-706.

Zhu, H.-R., Wu, P., Zhao, N., Wang, Y.-Z., & Qiu, Y.-C. (2009). Identification and analysis of disease resistance to powdery mildew and rust in some wheat germplasm resources. *Journal of Triticeae Crops*, *5*, 037.